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A GUIDE TO PROFITABLE TREE UTILIZATION

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In most of the southern pine region, each tree or portion of a tree can be sold for any one of several different products that vary widely in both value and production costs. Under these conditions, the forest manager strives to channel the various portions of his trees into those uses that will insure the greatest net return on the entire cut.

This report presents a guide for determining the most profitable products to take from a tree, once the decision has been made to cut the tree. Though the discussion is concerned with southern pine, the principles apply equally well to any tree species. Included as an appendix to the report are some data on conversion costs that may be used by southern pine managers in arriving at their utilization decisions.

The questions involved in determining the most profitable utilization of the tree are not particularly complex. Consideration of them does involve at the outset, however, recognition of the fact that fixed (overhead) costs play no part in the choice between alternate uses of the tree or its parts. With a little thought this fact may seem obvious, yet it can be and sometimes is overlooked. It is necessary, therefore, in developing a method for determining the most profitable utilization of the tree, to exclude fixed charges. This point can best be made by a simple, hypothetical illustration.

Paradox of the Expensive Profits

Lumber Company X operates a mill in the lower South and draws its entire cut of 10,000 M board feet of lumber annually from its own pine timberlands. Its fixed costs are $70,000, or $7 per M. Seventy percent of the cut comes from butt and middle logs having an average "realization value" of $40 per M. The other 30 percent comes from top logs with a negative realization value of $2 per M. These realization values are the difference between the selling price of the lumber and the total cost of logging, milling, and selling, including fixed costs prorated on a per-M basis. They represent the margin for stumpage, profit, and uninsured risks.

The annual net return on this operation is $274,000, or $27.40 per M board feet:

7,000 M at $40 per M	$280,000	
3,000 M at $ 2 per M loss	-6,000	
Net return	$274,000	($27.40 per M)

Feeling dissatisfied with this use of top logs, the company sells them to a pulpwood contractor for $3 per M in the woods, attached to the tree tops. This looks like a profitable arrangement --an opportunity to change a loss of $2 per M to a net return of $3 per M on 3,000 M. No effort is made to obtain timber to offset that diverted to pulpwood, and total production drops from 10,000 M board feet per year to 7,000 M.

At the end of the year, the company finds that in exchanging a $2 loss for a $3 gain it has reduced returns 60 cents per M on its entire cut. This paradox of expensive profits resulted from the fact that lowering mill output from 10,000 M to 7,000 M increased fixed costs from $7 per M to $10 per M ($70,000 divided by 7,000 M). Thus the average realization value for butt and middle logs has been reduced from $40 to $37 per M. The statement of net return stands as follows:

7,000 M at $37 per M	$259,000	
3,000 M at $ 3 per M	9,000	
	$268,000	($26.80 per M)

The method employed by the company to determine the best use of its logs was faulty because realization value is influenced by total output. What is needed is a method of determining best utilization that will give the correct answer irrespective of the total volume of production. Such a method is described below, and is termed the "method of conversion surplus."

Method of Conversion Surplus

In this method, each portion of a tree is assigned to that use which will yield the greatest surplus of sale value over the direct (variable) costs of conversion, exclusive of fixed charges. This difference will be referred to as "conversion surplus."

To illustrate, take an 18-inch southern pine tree 85 feet in total height and capable of being subdivided into five full 16-foot sections. This tree has been felled, and the question is to what use each of the five sections should be put. Some of them may be usable for sawlogs, some for other products, and still others may not be usable at all.

It will pay to buck out and utilize any section the return from which will at least cover the direct costs of conversion. 1/ Any such section will pay its way. Those sections that show a surplus above direct costs help defray fixed costs and increase profit. It follows that the most profitable use of a section will be that which yields the highest conversion surplus. 2/ The sale values, direct costs of conversion (excluding direct costs chargeable to the tree as a whole), and resulting conversion surpluses for each section of this tree are given in table 1 for two alternatives, lumber and pulpwood.

Table 1.--Best use of an 18-inch southern pine tree as determined by the method of conversion surplus, where lumber and pulpwood are the alternatives

16-foot section	Used for lumber			Used for pulpwood			Best use	
	Sale value 1/	Direct costs of conversion	Conversion surplus	Sale value 2/	Direct costs of conversion	Conversion surplus	Conversion surplus	Product
	Dollars							
Butt	14.50	7.00	7.50	3.35	1.75	1.60	7.50	lumber
2nd	8.75	5.00	3.75	2.65	1.50	1.15	3.75	lumber
3rd	6.00	4.00	2.00	2.10	1.25	.85	2.00	lumber
4th	3.25	3.50	-.25	1.75	1.00	.75	.75	pulpwood
5th	-	-	(3/)	.75	.80	-.05	-.05	cull

1/ Based on finished lumber prices f.o.b. cars at mill.
2/ Based on price of pulpwood f.o.b. cars.
3/ No need to calculate conversion surplus since zero surplus has already been passed at the fourth section.

1/ Cost of conversion is calculated as a total up to the stage in conversion to which sale value applies. Direct cost as distinguished from fixed cost includes those expenditures for labor, supplies, and the like which are directly chargeable to the log in question. Whether these direct costs will be incurred depends on whether the log is utilized. For a comprehensive discussion of the types of cost, see "Studies in the Economics of Overhead Costs," by J.M. Clark, Univ. of Chicago Press, 1923; and "Cost Behavior and Price Policy," by Conference on Price Research, National Bureau of Economic Research, New York, 1943.

The general principle that products, to be worth handling, must repay at least their direct costs of conversion has been applied to forest management problems by, among others, W. W. Ashe in "Adjustment of the Volume Removed in Selection Felling," Journal of Forestry 24: 862-873,1926; and D.M. Matthews in "Cost Control in the Logging Industry," McGraw-Hill, New York, 1942, pages 34-39.

2/ Of course, if operating facilities can be run to capacity on other sections that have a still higher conversion surplus, the section in question had best not be utilized in this operation.

It appears from table 1 that the best use of the first three sections is lumber and of the fourth section, pulpwood. The fifth section has a negative conversion surplus in both uses and should be left in the woods as cull.

Not included in the table are costs such as locating, marking, and felling the tree. These costs of harvesting are jointly incurred by all sections in the tree and must be charged to the tree as a whole. Prorating such joint costs among the sections of the tree may lead to error.

As an example, assume a 10-inch two-log pine tree whose logs have a total conversion surplus of $1.00. Eighty cents of this value is derived from the butt log and 20 cents from the top log. If the joint cost of 60 cents for marking and felling the tree is prorated to the logs either by number of logs (30 cents apiece) or by volume (36 cents to butt, 24 cents to top log), the top log has a negative conversion surplus and would appear to be a cull.

Such a conclusion would be erroneous. The total conversion surplus of this tree is the sum of the conversion surpluses of its logs ($1.00) minus the direct cost of marking and felling (60 cents), or 40 cents. The fact that this conversion surplus is positive indicates that the tree is worth felling. If the top log is culled, the total conversion surplus of the tree is reduced to 20 cents, which is another way of saying that the top log is worth taking.

Here, incidentally, it is seen that the method of conversion surplus may be used to segregate those trees that will not pay their own way. If the sum of the conversion surpluses of the logs in a tree does not equal or exceed the joint costs of harvesting, the tree is a cull.

Application of method to an integrated woods-mill operation

Using the method of conversion surplus as just developed for a single tree, the problem of Lumber Company X and the paradox of the expensive profits may now be resolved. An analysis of the prospective cut is made, with the trees separated into whatever classes are most useful--perhaps tree species, diameter, merchantable height, and log quality. In table 2 the analysis is made by tree-diameter class, with merchantable height and log quality averaged within each class.

For purposes of simplification, joint costs of marking and felling are charged to the butt log, and any negative surpluses so obtained are disregarded providing the tree as a whole has a positive conversion surplus. The table shows that when the entire harvest is sawn into lumber, 10-inch trees have a negative conversion surplus. Omitting top logs from consideration, however, leaves all sizes of trees with positive

Table 2.--Best use of southern pine trees by the X Lumber Company, as determined by the method of conversion surplus, where the alternatives are to manufacture lumber and to sell logs in the woods to a pulpwood contractor

Tree d.b.h. class (inches)	16-foot logs per tree	All logs--used for lumber				
		Volume	Sale value per M b.f.	Direct costs of conversion per M b.f.	Conversion surplus	
					Per M b.f.	Total
	Number	M b.f.	Dollars	Dollars	Dollars	Dollars
10	2	300	62.00	65	- 3.00	- 900
12	2	650	64.40	60	4.40	2,860
14	3	1,150	66.60	57	9.60	11,040
16	3	1,400	77.39	55	22.39	31,350
10-16						
18	3	1,750	89.57	53	36.57	64,000
20	3	2,000	90.45	50	40.45	80,900
22	3	1,500	96.67	45	51.67	77,500
24	3	1,250	101.80	40	61.80	77,250
18-24						
All classes		10,000				344,000

Tree d.b.h. class (inches)	16-foot logs per tree	All but top logs--used for lumber				
		Volume	Sale value per M b.f.	Direct costs of conversion per M b.f.	Conversion surplus	
					Per M b.f.	Total
	Number	M b.f.	Dollars	Dollars	Dollars	Dollars
10	2	180	68	63	5	900
12	2	390	71	57	14	5,460
14	3	730	73	55	18	13,140
16	3	950	86	53	33	31,350
10-16						
18	3	1,250	96	48	48	60,000
20	3	1,450	97	45	52	75,400
22	3	1,100	105	40	65	71,500
24	3	950	110	35	75	71,250
18-24						
All classes		7,000				329,000

Tree d.b.h. class (inches)	16-foot logs per tree	Top logs					
		Volume	Used for lumber				Sold as pulpwood--total conversion surplus at $3 per M b.f.
			Sale value per M b.f.	Direct costs of conversion per M b.f.	Conversion surplus		
					Per M b.f.	Total	
	Number	M b.f.	Dollars	Dollars	Dollars	Dollars	Dollars
10	2	120	55	70	- 15	- 1,800	360
12	2	260	58	68	- 10	- 2,600	780
14	3	420	60	65	- 5	- 2,100	1,260
16	3	450	63	63	0	0	1,350
10-16		1,250				- 6,500	3,750
18	3	500	64	56	8	4,000	1,500
20	3	550	65	55	10	5,500	1,650
22	3	400	65	50	15	6,000	1,200
24	3	300	65	45	20	6,000	900
18-24		1,750				21,500	5,250
All classes		3,000				15,000	9,000

(Agric.--Atlanta)

conversion surpluses. These surpluses are greater per M than the $3 received from the pulpwood contractor. Judgment indicates that, by themselves, middle logs of three-log trees have a conversion surplus for lumber greater than the contractor's price, and therefore need not be analyzed separately.

This narrows to top logs the search for material that has been diluting profits. Further analysis shows that top logs from 18-inch and larger trees have a favorable conversion surplus as lumber, but that top logs of smaller trees are better channeled into pulpwood. The best utilization therefore is:

7,000 M of butt and middle logs: lumber	$329,000
1,750 M of top logs: lumber	21,500
1,250 M of top logs: pulpwood	3,750
Total conversion surplus	$354,250
Fixed costs	-70,000
Net return	$284,250 ($28.42 per M)

Proper utilization thus increases net return by $10,250, since the return when all logs were taken for lumber was $274,000.

Even with reduced production at the sawmill, which increases the overhead burden on the remainder of the cut, the utilization decisions arrived at by the conversion-surplus method have increased the net return. In effect, producers can safely ignore overhead costs in reaching utilization decisions, for the conversion-surplus method invariably results in the greatest amount of money from a given cut of timber to be applied to fixed costs, stumpage, profit, and uninsured risks.

Correct application of the method insures that the diversified raw material cut from the forest will be put to alternative uses yielding the highest net return. Further, an analysis of operations by the conversion-surplus method, with log or tree grade used as one of the classifications, may also result in utilizing a greater length of the bole than is normally considered profitable. Such an analysis will also identify the smallest size and poorest quality of tree that may profitably be removed on its own merits in thinning and stand improvement.

The more precisely that material is identified--as the breaking down of trees or logs into diameter classes and into quality classes within a diameter class--the more accurate will be the determination of best utilization. If a large volume or value of timber is involved, it may pay to apply the analysis in as much detail as possible. The limits to which the analysis should go can be decided by weighing possible increases in conversion surplus against the expense of determining them.

Where use of the conversion-surplus method would reduce plant operation below capacity, the method may be employed to determine the price that may be paid on the open market for stumpage or logs to keep the mill running. If the buyer can get such timber for less than its conversion surplus to him, he can increase his total net return by purchasing it.

Needless to say, use of the method does not insure a net profit. Where profits are possible, it will point the way to the greatest profit. Otherwise it will merely insure that loss is minimized.

Application of method by non-manufacturing stumpage producers

The method of conversion surplus applies equally well to a forest business selling logs. An example is Company Y, operating 10,000 acres of mixed southern pine and hardwoods. The allowable yearly cut under management is 2,500 M of logs from trees 10 inches d.b.h. and larger. The fixed costs are $15,000 per year. The company's policy has been to cut and deliver logs to a sawmill rather than sell stumpage. Currently, $40 per M, Doyle rule, is being received for all logs delivered, regardless of size, species, or quality. The company has the alternative of selling pulpwood on cars for $12 per standard cord. Its problem is to determine which logs should be sold as sawlogs and which as pulpwood.

Using the method of conversion surplus, the company finds that 10-inch trees and the top logs from 12-inch to 16-inch trees, inclusive, should be cut into pulpwood. The remainder of the cut should be sold as sawlogs. The calculation is shown in table 3; judgment indicates that the middle logs are clearly best sold as sawlogs and need not be analyzed separately. Net return from this system of utilization is:

10-inch trees: pulpwood	$ 1,640
Top logs from 12-inch through 16-inch trees: pulpwood	3,913
Remainder of crop: sawlogs	50,053
Total conversion surplus	$55,606
Fixed cost	-15,000
Net return	$40,606

This net return is more than $5,600 greater than that obtained from the current practice of putting everything into sawlogs, in which the total conversion surplus of $50,000 less fixed costs of $15,000 yields a net return of only $35,000.

In order to make these comparisons between sawlogs and pulpwood, it was necessary for Company Y to express all sale values in terms of

Table 3.--Best use of trees by Company Y as determined by method of conversion surplus, when the alternatives are to sell sawlogs at $40 per M bd. ft. Doyle or to sell pulpwood at $12 per standard cord

Tree d.b.h. class (inches)	16-foot logs per tree	All logs --sold as sawlogs			
		Volume	Direct costs of conversion per M bd. ft.	Conversion surplus	
				Per M bd. ft.	Total
	Number	M bd. ft.	Dollars	Dollars	Dollars
10	2	100	50	- 10	- 1,000
12	2	200	34	6	1,200
14	3	400	25	15	6,000
16	3	500	20	20	10,000
18	3	650	15	25	16,250
20	3	650	13	27	17,550
		2,500			50,000

Tree d.b.h. class (inches)	All but top logs							
	Vol-ume	Sold as sawlogs			Sold as pulpwood			
		Direct costs of conversion per M board feet	Conversion surplus		Sale value per M bd. ft.	Direct costs of conversion per M board feet	Conversion surplus	
			Per M bd. ft.	Total			Per M bd. ft.	Total
	M bd.ft.	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
10	50	35	5	250.00	56.40	37.60	18.80	940.00
12	138	30	10	1,380.00	36.00	27.00	9.00	1,242.00
14	328	22	18	5,904.00				
16	390	17	23	8,970.00				
18	500	13	27	13,500.00				
20	514	11	29	14,906.00				
	1,920			44,910.00				

Tree d.b.h. class (inches)	Top logs							
	Vol-ume	Sold as sawlogs			Sold as pulpwood			
		Direct costs of conversion per M board feet	Conversion surplus		Sale value per M bd. ft.	Direct costs of conversion per M board feet	Conversion surplus	
			Per M bd. ft.	Total			Per M bd. ft.	Total
	M bd.ft.	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
10	50	65.00	- 25.00	-1,250.00	42.00	28.00	14.00	700.00
12	62	42.90	- 2.90	- 179.80	60.00	40.00	20.00	1,240.00
14	72	38.67	1.33	95.76	66.00	44.00	22.00	1,584.00
16	110	30.63	9.37	1,030.70	39.60	29.70	9.90	1,089.00
18	150	21.67	18.33	2,749.50	37.20	27.90	9.30	1,395.00
20	136	20.56	19.44	2,643.84	36.00	27.00	9.00	1,224.00
	580			5,090.00				7,232.00

(Agric.--Atlanta)

a common unit of measure. As was seen in table 3, the company used M board feet, Doyle rule, for this purpose.

Use of Conversion-Surplus Method in the Woods

The illustrations given for Company X and Company Y show that it is not necessary to consider fixed costs in determining the utilization that will yield maximum net return. This point was most easily demonstrated by dealing with average trees so as to be able to pass over the variability of trees in height and quality within each d.b.h. class. A similar approach (using average trees) would be useful for any operator who wanted to map out a utilization policy and predict its effect upon his net return.

In using the method in the woods, however, the forest manager would take a somewhat different approach. He would compute the conversion surpluses (say for sawlogs and pulpwood) of individual logs of each diameter and grade. From these conversion surpluses he would determine the breaking points between sawlog and pulpwood use in terms of diameter within each grade. He would also locate the breaking points between pulpwood and cull.

Having established these points, the forest manager would give them to his woods foreman for use in guiding the logging. For many operators, such a determination of breaking points for individual logs would satisfy the entire need for utilization analysis.

Other Applications of Conversion-Surplus Method

The same principles as illustrated above for sawlogs and pulpwood apply where veneer, poles, piling, or any other products are included among the alternatives.

Sawmilling companies frequently have to decide between selling their high-grade trees to pole and piling producers and others or sawing them into the long, wide, high-grade boards that help to move a cut of lumber on the market. The method of conversion surplus applies to such problems. Tree diameter classes can be broken down into quality classes on the basis of log grades and assigned values that recognize the true worth of high-grade material. The trees that can more profitably be sold than sawn into lumber can then be determined by comparing their conversion surpluses.

In applying the conversion surplus method to stumpage purchased on a log-scale basis, the purchaser should handle the stumpage price as a direct cost. But if he buys, for a lump sum, either marked timber or timber to a diameter limit, the purchase price can be ignored in determining the most profitable tree utilization. The purchase price in these two instances is a cost covering the entire operation and must

not be allocated to individual logs or even to individual trees. It is therefore regarded as a fixed cost, not as a direct cost.

An interesting corollary to this analysis occurs where stumpage is sold on a log-scale basis for a fixed price per unit of measure. Such a price, added to the other direct costs of production, lends a negative conversion surplus to a portion of the material in felled trees that might otherwise be used to the advantage of both seller and buyer. Either the lump-sum sale or the log-scale transaction with prices adjusted for log size and quality may escape this disadvantage.

Appendix: Cost Data for Southern Pine

The method of conversion surplus as presented in this paper calls for the use of data on direct (as distinguished from fixed) costs of conversion. Such data are scarce for southern pine and almost nonexistent for other southern species. Some of the available data on direct costs of producing loblolly and shortleaf pine lumber and pulpwood are assembled here. The derivation of these data is explained in some detail so that they may, if necessary, be adapted to different conditions from those to which they directly apply.

The chief item in direct cost of timber conversion is labor, and this factor is therefore given primary emphasis in the following tables. Labor cost is expressed in man-hours, so that any hourly rate may be used to arrive at a dollar cost. Unfortunately the source data do not permit a separation of labor requirements in felling from those in bucking and limbing.

Items of direct cost other than labor are expressed in 1945 or 1946 dollars. They cover supplies and equipment directly consumed and chargeable to the material handled.

Pulpwood from small trees

Table 4 gives some data on direct costs of producing 5-foot pulpwood from pine trees 5 to 15 inches d.b.h., inclusive.

Table 4.--Direct costs per standard rough cord of producing pulpwood from southern pine trees

Tree d.b.h. (inches) (1)	Volume per tree (2)	Labor costs: Felling, bucking, limbing (3)	Labor costs: Loading, unloading (4)	Labor costs: Hauling (5)	Labor costs: Total stump to cars (6)	Costs other than labor (7)
	Cords	Man-hours	Man-hours	Man-hours	Man-hours	Dollars
5	.022	5.22	2.10	2.10	9.42	2.53
6	.038	4.58	1.80	2.10	8.48	2.53
7	.060	3.86	1.58	2.10	7.54	2.53
8	.095	3.36	1.41	2.10	6.87	2.53
9	.113	3.10	1.30	2.10	6.50	2.53
10	.135	2.97	1.25	2.10	6.32	2.53
11	.172	2.92	1.21	2.10	6.23	2.53
12	.204	2.92	1.19	2.10	6.21	2.53
13	.244	2.98	1.16	2.10	6.24	2.53
14	.283	3.06	1.15	2.10	6.31	2.53
15	.324	3.14	1.16	2.10	6.40	2.53

Columns 2 through 4 were adapted from Cuno (1),[1] columns 2 and 3 from his table 2, and column 4 from his table 7.

Column 5 was taken from Reynolds (4), table 4. Minutes per load were calculated for a 20-mile haul, stump to cars, as follows for the round trip:

	Minutes
2 miles of woods road at 11.35 minutes per mile	22.7
8 miles of graded dirt road at 3.95 minutes per mile	31.6
30 miles of gravel or hard road at 2.35 minutes per mile	70.5
40-mile round trip	124.8

Assuming 2 men accompanying a load and 1.98 cords per load, a requirement of 2.10 man-hours per cord was arrived at.

Column 7 covers direct costs other than labor--principally for gas, oil, tires, and the like consumed in hauling; other non-labor items are negligible. Cost per load was calculated first, from Reynolds (5), table 3:

	Dollars
2 miles of woods road at 20.5 cents per mile	0.410
38 miles of other road at 12.1 cents per mile	4.598
40-mile round trip	5.008

Cost per cord was then figured on the basis of 1.98 cords per load. This cost is in 1945 dollars.

Pulpwood from saw-timber tops

Where pine pulpwood is produced, not from entire trees, but from upper stems of sawlog trees, table 5 may be used. Here the material is segregated on the basis of small-end diameter, inside bark. The data were compiled on the basis of 16-foot sections taken from the tops of trees 10 through 24 inches d.b.h. and cut into 5-foot sticks.

1/ Underlined numbers in parentheses refer to sources listed at the end of this section.

Table 5.--Direct costs per standard rough cord of producing pulpwood from southern pine tops

Small-end diameter, i.b., of 16-foot section (inches) (1)	Volume per 16-foot section (2)	Labor costs: Bucking, limbing, splitting (3)	Labor costs: Loading, unloading (4)	Labor costs: Hauling (5)	Labor costs: Total, stump to cars (6)	Costs other than labor (7)
	Cords	Man-hours				Dollars
5	.038	2.11	1.70	2.10	5.91	2.53
6	.055	2.20	1.40	2.10	5.70	2.53
7	.061	2.39	1.25	2.10	5.74	2.53
8	.098	2.76	1.15	2.10	6.01	2.53
9	.120	3.52	1.13	2.10	6.75	2.53
10	.156	5.03	1.10	2.10	8.23	2.53
11	.195	7.80	1.10	2.10	11.00	2.53
12	.214	9.55	1.10	2.10	12.75	2.53

Column 3 was adapted from Reynolds, Bond, and Kirkland (6), table 39. Columns 4, 5, and 7 were taken from table 4 above, column 4 being adjusted on the basis of judgment.

Circular-Sawmill Operation

In table 6 are some direct-cost data covering the production of pine sawlogs and their conversion into rough green lumber at an efficient medium-size circular sawmill. This mill is equipped with edgers, trimmers, and dipping vats, and strikes a reasonable balance between cutting for volume and cutting for grade. The operation is traced from stump to green, dipped lumber loaded on trailers ready for hauling to the finishing plant. In order to make the data as useful as possible, they are shown for standard 16-foot logs of scaling diameters 6 through 18 inches. Quality is disregarded on the assumption that there is practically no difference in conversion costs between high- and low-quality logs of a given size.

Columns 2 through 5 were adapted from Reynolds, Bond, and Kirkland. Columns 2, 3, and 4 were adapted from their table 54, adjusted to per-log volumes reported by Gregory and Person (2), table 7 Column 5 (truck stand-by time) includes the driver's time during the locating of the set, loading, and unloading; the data were adapted from Reynolds, Bond, and Kirkland, table 60, again adjusted to per-log volume.

Table 6.--Direct costs per M board feet, green lumber tally, of producing southern pine sawlogs and lumber: circular sawmill operation

LABOR COSTS

Scaling diam. of 16-ft. log (inches) (1)	Felling, bucking, limbing (2)	Skidding (3)	Truck loading (4)	Truck stand-by time during loading (5)	Truck hauling (6)	Total, stump to log yard (7)	Milling (8)	Total, stump to lumber trailer (9)
				Man-hours				
6	4.42	3.32	1.24	1.71	1.47	12.16	10.17	22.33
7	3.55	2.47	.92	1.48	1.44	9.86	8.72	18.58
8	2.98	1.91	.71	1.26	1.41	8.27	7.93	16.20
9	2.58	1.46	.54	1.04	1.37	6.99	7.33	14.32
10	2.29	1.15	.43	.84	1.33	6.04	6.83	12.87
11	2.26	1.00	.40	.74	1.31	5.71	6.51	12.22
12	2.05	.82	.33	.62	1.27	5.09	6.28	11.37
13	1.87	.68	.29	.53	1.23	4.60	6.05	10.65
14	1.73	.58	.25	.50	1.19	4.25	5.87	10.12
15	1.60	.50	.22	.47	1.15	3.94	5.73	9.67
16	1.51	.45	.20	.45	1.10	3.71	5.54	9.25
17	1.35	.38	.18	.42	1.04	3.37	5.41	8.78
18	1.25	.34	.16	.40	.98	3.13	5.33	8.46

COSTS OTHER THAN LABOR

Scaling diam. of 16-ft. log (inches) (1)	Felling, bucking, limbing (10)	Skidding, truck loading (11)	Truck hauling (12)	Total, stump to log yard (13)	Milling (14)	Total, stump to lumber trailer (15)
				Dollars		
6	0.21	2.05	4.84	7.10	0.95	8.05
7	.17	1.53	4.82	6.52	.93	7.45
8	.14	1.18	4.80	6.12	.90	7.02
9	.12	.90	4.76	5.78	.87	6.65
10	.11	.71	4.68	5.50	.84	6.34
11	.11	.63	4.63	5.37	.81	6.18
12	.10	.52	4.54	5.16	.78	5.94
13	.09	.44	4.40	4.93	.75	5.68
14	.08	.37	4.26	4.71	.71	5.42
15	.08	.32	4.10	4.50	.68	5.18
16	.07	.29	3.90	4.26	.64	4.90
17	.06	.25	3.52	3.83	.61	4.44
18	.06	.22	3.12	3.40	.57	3.97

Column 6 (truck hauling) was computed from Reynolds (4), table 4, as follows for the round trip of 40 miles:

	Minutes
2 miles of woods road at 10.55 minutes per mile	21.1
8 miles of graded dirt road at 4.3 minutes per mile	34.4
30 miles of gravel or hard road at 2.25 minutes per mile	67.5
40-mile round trip	123.0

This figure of minutes per load was converted to man-hours on the assumption that only one man accompanies the load. Man-hours per load were converted to man-hours per M on the basis of Reynolds, Bond, and Kirkland, table 60.

Column 8 was adapted from Gregory and Person, table 23. Sawing time as given in this table was converted to man-hours on the basis of a working force of 22 men (Gregory and Person, page 5).

Columns 10 through 12, covering direct logging costs other than labor, are expressed in 1945 dollars. The data are taken from Reynolds (5). Column 10 is derived from the following items in his table 1, the costs being expressed in cents per two-man crew-hour:

	Cents
Supplies (oil, wedges, etc.)	3.3
Maintenance of saws and axes	6.3
Total	9.6

This factor was converted to a man-hour basis and multiplied by the figures in column 2. Column 11 was similarly derived from columns 3 and 4 and Reynolds' table 2. Column 12 is based on per-load costs given in Reynolds' table 4:

	Dollars
2 miles of woods road at 31.2 cents per mile	0.624
38 miles of other road at 17.5 cents per mile	6.650
40-mile round trip	7.274

Using conversion factors derived from Reynolds, Bond, and Kirkland, table 60, and Gregory and Person, table 7, this per-load cost was converted to a per-M basis for each log-scaling diameter.

Column 14 was adapted from Gregory and Person, table 22, and is expressed in 1945 dollars. The following were taken as items of direct cost:

	Dollars
Oil	544.80
Small supplies and repairs	2,816.28
Gas, electricity, and water	1,338.22
	4,699.30

This total direct cost per year was converted to cost per M by the use of 2,418 operating hours (Gregory and Person, page 30) and factors of time per M (table 23), to which was added 17 cents per M for stain preventive.

Band-sawmill operation

Some data on direct costs of producing pine sawlogs and converting them to finished lumber at a band mill are given in table 7. The sawmill is equipped with resaws, edgers, trimmers, and diversified finishing machinery, and an effort is made to get high lumber-grade recovery. The operation is traced from stump to finished lumber loaded on box cars. All costs are expressed per M board feet of finished lumber for 16-foot logs of scaling diameters 8 through 20 inches.

Columns 2 through 6 of table 7 were derived from the same sources as used for table 6, except that per-log volumes were taken from Reynolds, Bond, and Kirkland, table 28. This use of table 28, which is based upon unfinished lumber from logs of various lengths averaging shorter than 16 feet, was justified by the fact that the table's understatement of tally as applied to 16-foot logs is approximately equal to its overstatement of tally as applied to finished lumber.

Column 8 is adapted from Reynolds, Bond, and Kirkland, table 20, adjusted on the basis of per-log volumes from their table 28.

Column 9 is taken from Lowther and Murray (3, p. 949).

Columns 11 and 12 are based upon the same factors of cost per man-hour as used to derive columns 10 and 11 of table 6; these cost factors were multiplied by the man-hour data in columns 2 through 4 of table 7.

Column 13 was derived from the same sources as used for column 12 of table 6, except that per-log volumes were taken from Reynolds, Bond, and Kirkland, table 28.

Column 15 is based upon a 1946 average cost of $2.20 published by the Southern Pine Association (7, p. 4). This average cost was divided

Table 7.--Direct costs per M board feet, finished lumber tally, of producing southern pine sawlogs and lumber: band sawmill operation

LABOR COSTS

Scaling diam. of 16-ft. log (inches) (1)	Felling, bucking, limbing (2)	Skidding (3)	Truck loading (4)	Truck stand-by time during loading (5)	Truck hauling (6)	Total, stump to log yard (7)	Milling (8)	Finishing, loading (9)	Total, stump to box cars (10)
	Man-hours								
8	2.65	1.70	0.64	1.12	1.26	7.37	4.57	15.40	27.34
9	2.72	1.53	.58	1.09	1.44	7.36	4.22	15.40	26.98
10	2.72	1.36	.52	1.00	1.58	7.18	4.00	15.40	26.58
11	2.70	1.19	.48	.88	1.56	6.81	3.76	15.40	25.97
12	2.56	1.03	.41	.77	1.59	6.36	3.58	15.40	25.34
13	2.39	.87	.37	.68	1.58	5.89	3.38	15.40	24.67
14	2.19	.74	.31	.63	1.51	5.38	3.21	15.40	23.99
15	2.01	.63	.28	.59	1.44	4.95	3.07	15.40	23.42
16	1.87	.55	.25	.56	1.36	4.59	2.98	15.40	22.97
17	1.73	.49	.23	.54	1.33	4.32	2.89	15.40	22.61
18	1.63	.45	.21	.52	1.27	4.08	2.82	15.40	22.30
19	1.58	.42	.20	.50	1.17	3.87	2.77	15.40	22.04
20	1.52	.40	.18	.46	1.08	3.64	2.73	15.40	21.77

COSTS OTHER THAN LABOR

Scaling diam. of 16-ft. log (inches) (1)	Felling, bucking, limbing (11)	Skidding, truck loading (12)	Truck hauling (13)	Total, stump to log yard (14)	Milling (15)	Finishing, (16)	Total, stump to box cars (17)
	Dollars						
8	0.13	1.06	4.79	5.98	2.80	1.72	10.50
9	.13	.95	4.77	5.85	2.62	1.72	10.19
10	.13	.84	4.74	5.71	2.51	1.72	9.94
11	.13	.75	4.70	5.58	2.39	1.72	9.69
12	.12	.65	4.64	5.41	2.30	1.72	9.43
13	.11	.56	4.56	5.23	2.20	1.72	9.15
14	.11	.47	4.46	5.04	2.12	1.72	8.88
15	.10	.41	4.33	4.84	2.05	1.72	8.61
16	.09	.36	4.18	4.63	2.00	1.72	8.35
17	.08	.33	3.99	4.40	1.95	1.72	8.07
18	.08	.30	3.76	4.14	1.92	1.72	7.78
19	.08	.28	3.30	3.66	1.89	1.72	7.27
20	.07	.27	3.12	3.46	1.87	1.72	7.05

into two parts. One part was assumed to vary directly with milling time per M. To handle this part, $1.70 was assigned to the average log (13 inches, as computed from Reynolds, Bond, and Kirkland, table 16), and amounts were assigned to logs of other diameters in proportion to the man-hour data in column 8. The second part of average cost, $0.50, was assumed to be constant per M. It was therefore added uniformly to each of the amounts arrived at above.

Column 16 is based upon 1946 data of the Southern Pine Association, page 4.

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